



Cross-Governmental Collaboration: Characterization of emissions and exposure due to 3D printing

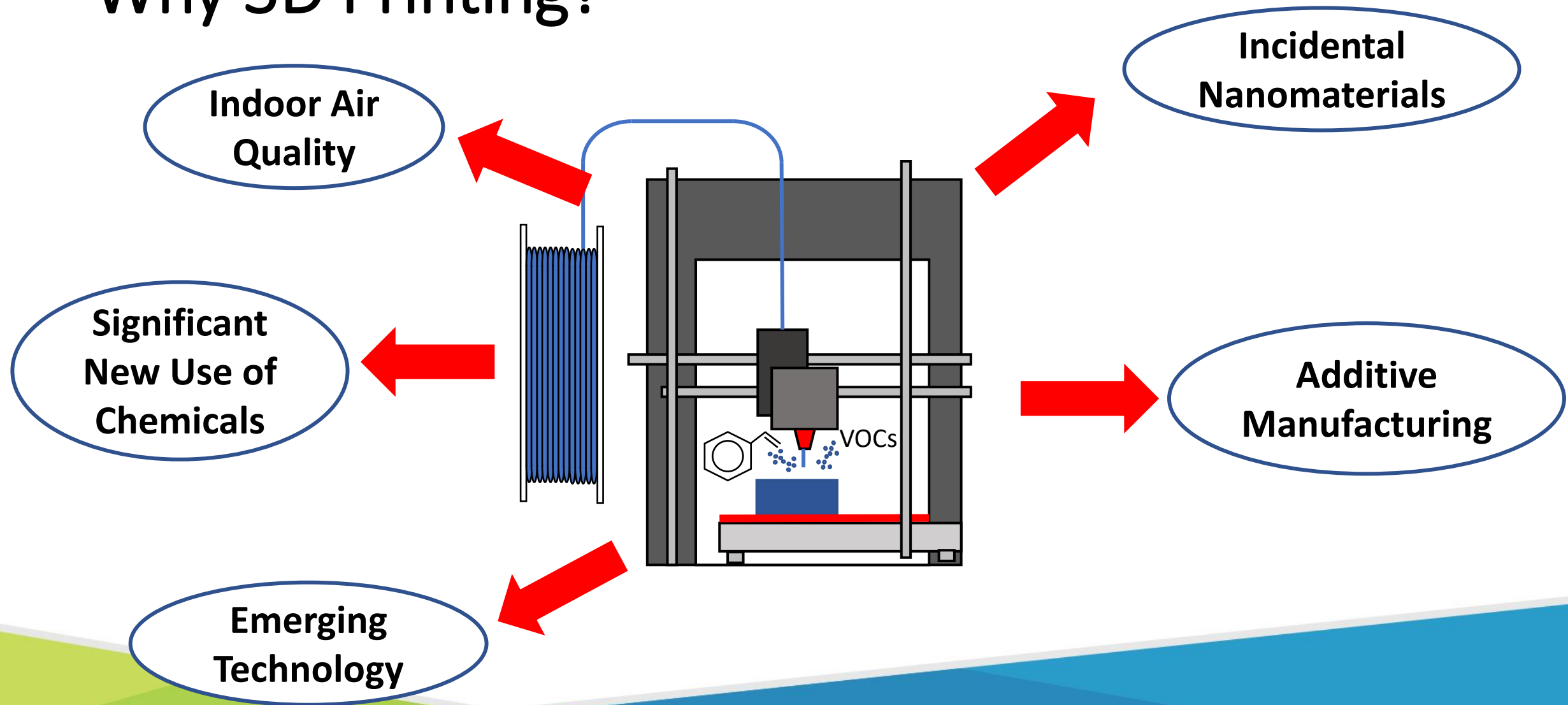
CSS.3.1 Emerging Materials and Technologies

November 4, 2021

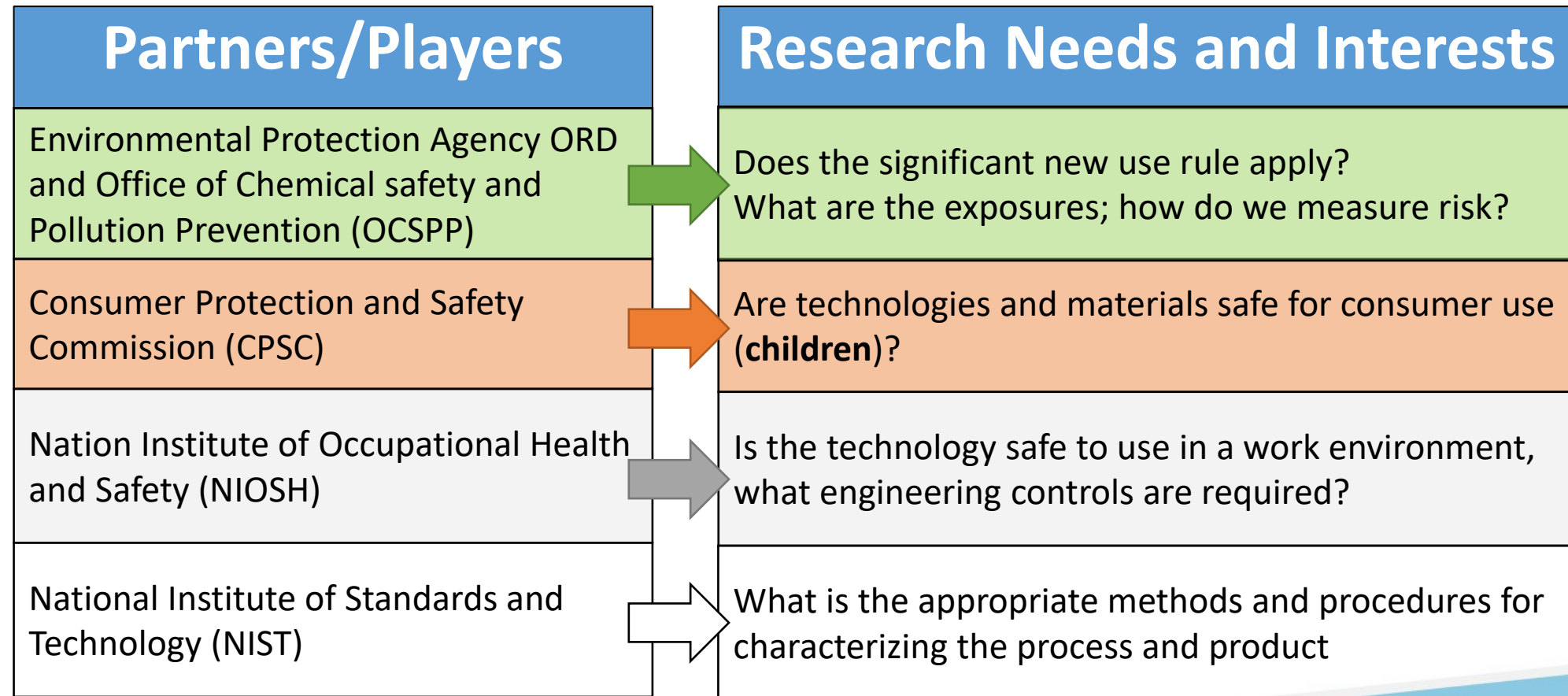
Todd Luxton

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Why 3D Printing?

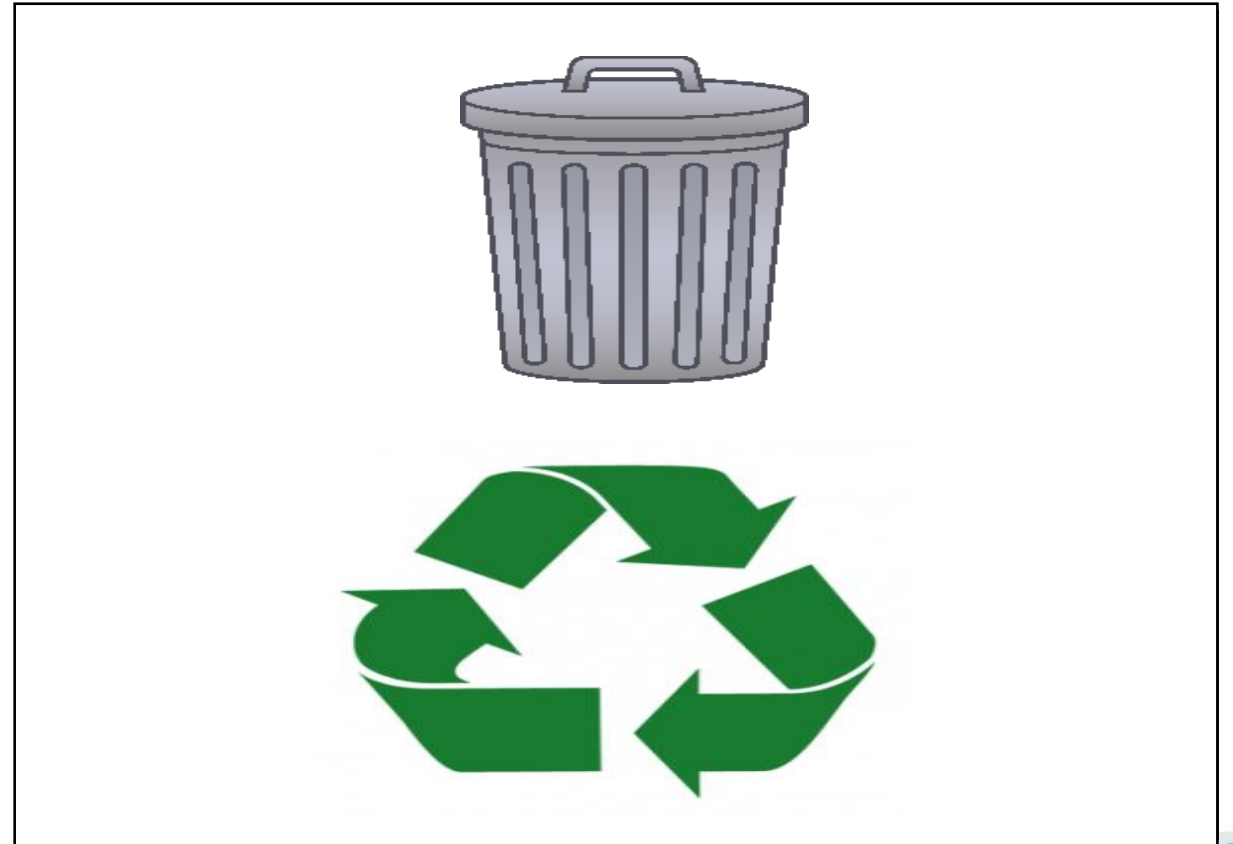


Who is Involved?



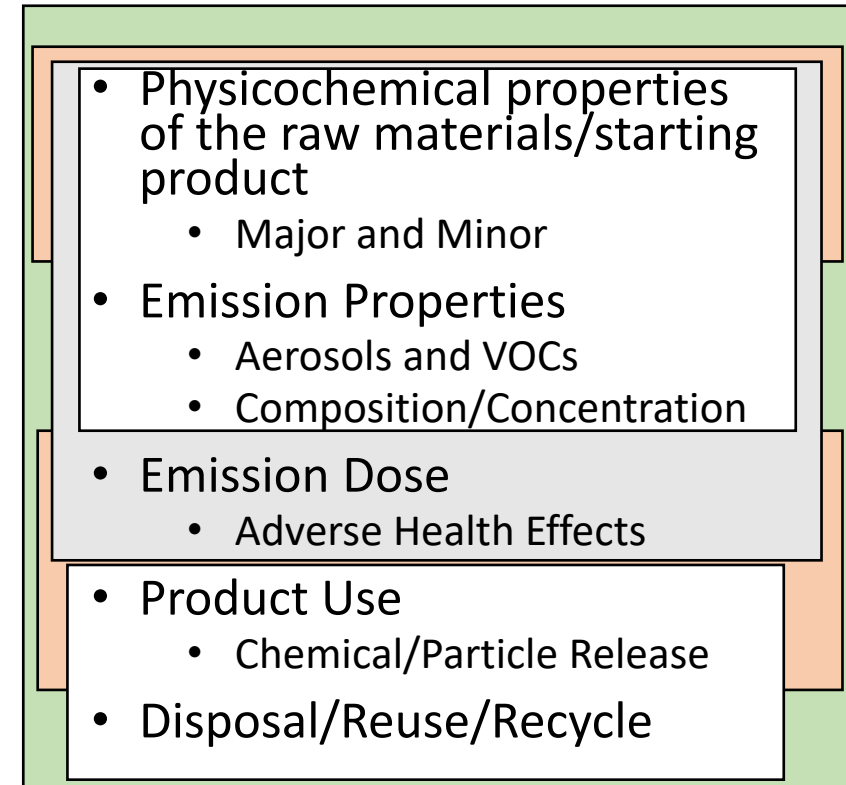
What do We Need to Know?

- Physicochemical properties of the raw materials/starting product
 - Major and Minor
- Emission Properties
 - Aerosols and VOCs
 - Composition/Concentration
- Emission Dose
 - Adverse Health Effects
- Product Use
 - Chemical/Particle Release
- Disposal/Reuse/Recycle



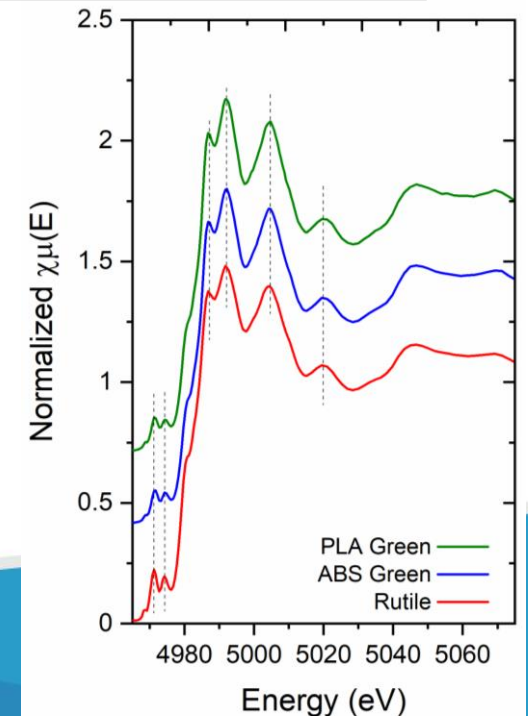
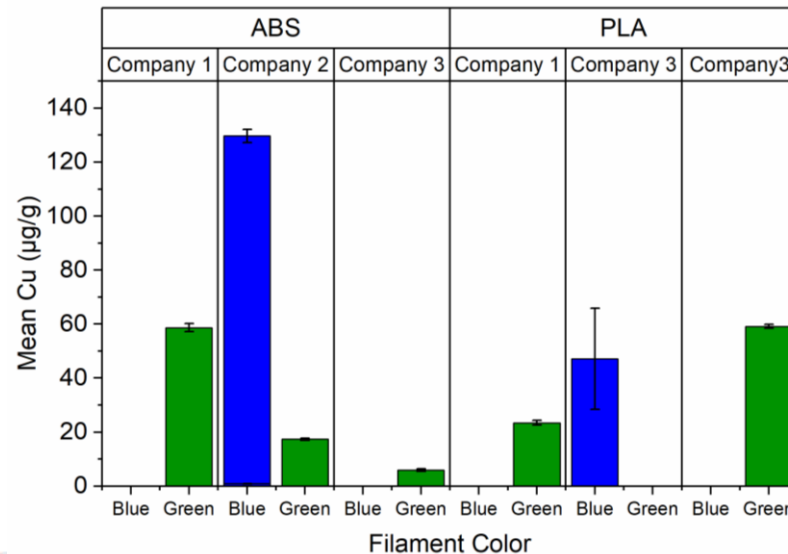
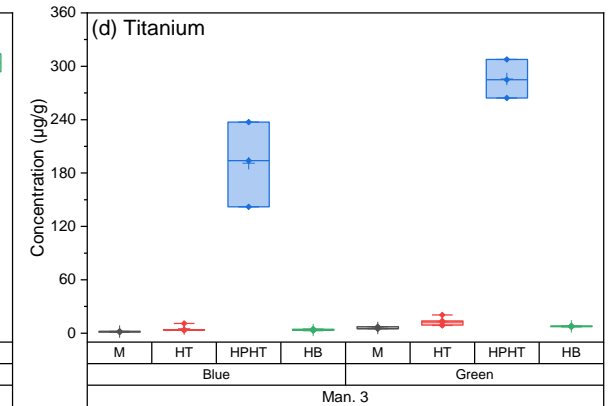
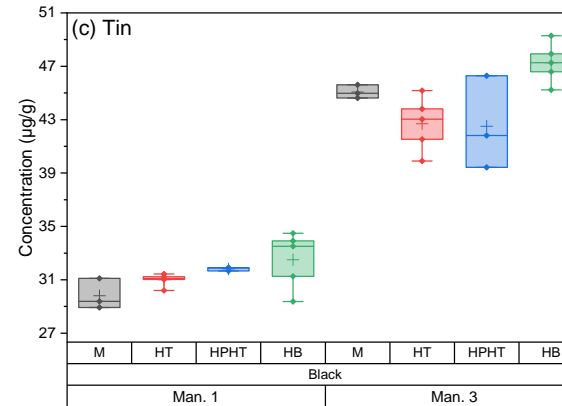
How is the Research Structured?

- Each Agency is utilizing unique expertise and technology to address specific data and research needs
- Intra-Agency work group established in 2019
 - Future Meeting Dec 2021
- Intra-Agency Agreements (CPSC-EPA)



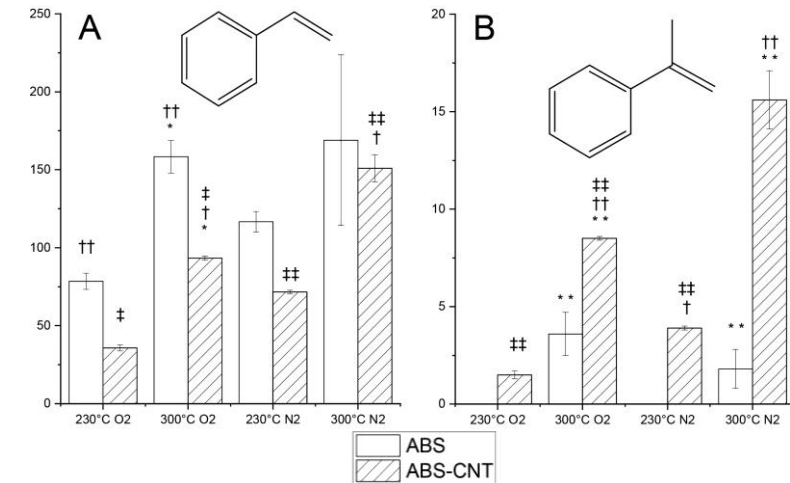
EPA Research Efforts

- Inorganic Composition and Concentration
 - Method Development for complete digestions
 - Quantification of inorganics present as function of polymer and manufacturer, color, additive
 - Chemical Speciation of metals present in filaments

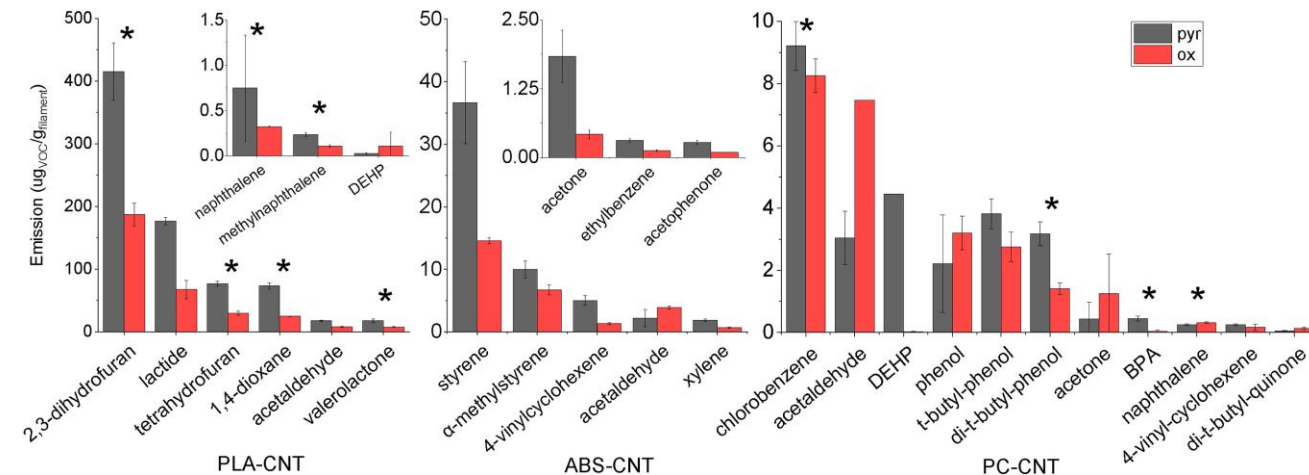


EPA Research Efforts

- Complete VOC Emission Profile
 - Closed system combustion allows for complete transfer of all reaction products
 - New reaction products discovered
- Influence of Additives on VOC emission profile
 - Additives alter emission profile
 - CNTs increase hazardous compound emissions
 - Chlorinated VOCs identified
 - Non-advertised additives present (silanol-copolymers)



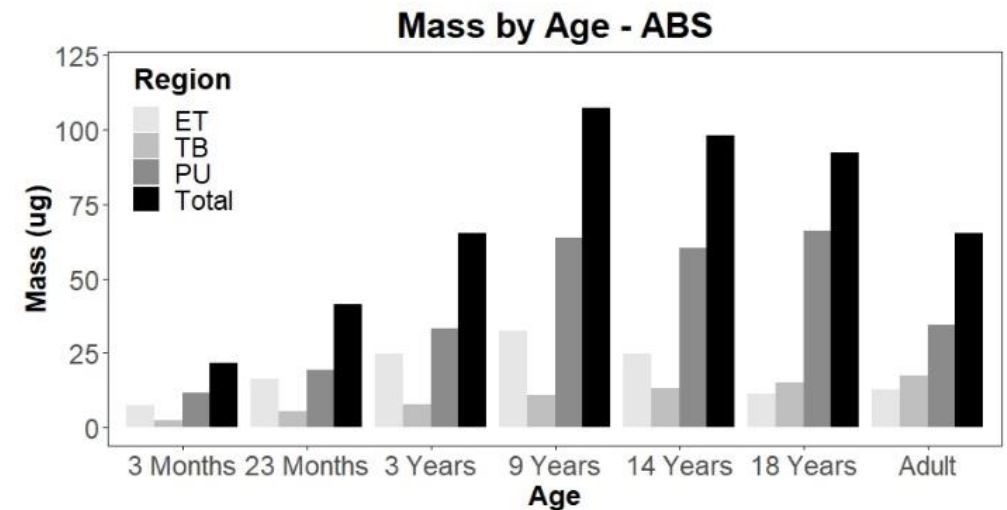
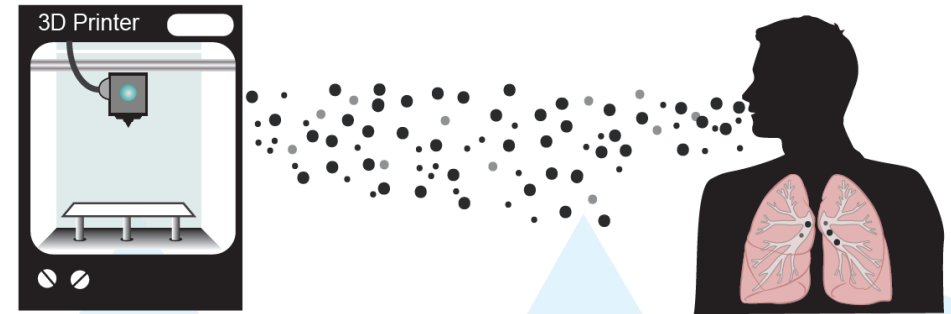
DOI: 10.1021/acs.est.9b00765




<https://doi.org/10.1016/j.chemosphere.2021.130543>

EPA Research Efforts

- Exposure Assessment
 - Meta –Analysis published data provided first comprehensive review of data
- Exposure Modeling
 - Translation of emission data from 3D printing to internal dose
 - Modeling efforts demonstrate impacts of age on exposure and lung burden



Future EPA Research Efforts

- Determination of inorganic partitioning into the aerosol phase
 - Identification of the inorganic and organic composition of 3D printer aerosols
 - Evaluation of the impacts of trace metal on VOC emissions
 - Evaluation of *in-vitro* cellular response of aerosols
 - Determination of chemical release from 3D printed objects and impacts of chemical and physical aging
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EPA Strengths and Critical Role

- Chemistry
 - State Of the Art Equipment
 - Expertise in Both Inorganic and Organic Chemistry
- Nanoscience
 - State of the Art Equipment
 - Expertise in Materials Characterization
 - Expertise in Detection and Quantification of Nanomaterials
- Exposure Science
 - Expertise in quantifying exposure at environmentally conditions

EPA Products

Seven peer reviewed publications in the past two years with 108 citations

- Byrley, P., W. K. Boyes, K. Rogers and A. M. Jarabek (2021). "3D printer particle emissions: Translation to internal dose in adults and children." *Journal of Aerosol Science*: 105765.
- Byrley, P., M. A. Geer Wallace, W. K. Boyes and K. Rogers (2020). "Particle and volatile organic compound emissions from a 3D printer filament extruder." *Science of The Total Environment* 736: 139604.
- Byrley, P., B. J. George, W. K. Boyes and K. Rogers (2019). "Particle emissions from fused deposition modeling 3D printers: Evaluation and meta-analysis." *Science of the Total Environment* 655: 395-407.
- Potter, P. M., S. R. Al-Abed, F. Hasan and S. M. Lomnicki (2021). "Influence of polymer additives on gas-phase emissions from 3D printer filaments." *Chemosphere* 279: 130543.
- Potter, P. M., S. R. Al-Abed, D. Lay and S. M. Lomnicki (2019). "VOC Emissions and Formation Mechanisms from Carbon Nanotube Composites during 3D Printing." *Environmental Science & Technology* 53(8): 4364-4370.
- Stefaniak, A. B., L. N. Bowers, A. K. Knepp, T. P. Luxton, D. M. Peloquin, E. J. Baumann, J. E. Ham, J. R. Wells, A. R. Johnson, R. F. LeBouf, F. C. Su, S. B. Martin and M. A. Virji (2019). "Particle and vapor emissions from vat polymerization desktop-scale 3-dimensional printers." *Journal of Occupational and Environmental Hygiene* 16(8): 519-531.
- Yi, J. H., M. G. Duling, L. N. Bowers, A. K. Knepp, R. F. LeBouf, T. R. Nurkiewicz, A. Ranpara, T. P. Luxton, S. B. Martin, D. A. Burns, D. M. Peloquin, E. J. Baumann, M. A. Virji and A. B. Stefaniak (2019). "Particle and organic vapor emissions from children's 3-D pen and 3-D printer toys." *Inhalation Toxicology*: 14.



Questions